PATENT SPECIFICATION

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(54) METHOD AND APPARATUS FOR SEPARATING NODULES FROM WATER OR FROM A MIXTURE OF WATER AND AIR

(71) We DEEPSEA VENTURES, INC., of Gloucester Point, Virginia 23062, United States of America, a corporation organised and existing under the laws of the State of Delaware, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to the separation of solid particles from fluid mixtures and is concerned particularly with an improved method of and apparatus for separation of that kind, which is especially applicable in underwater mining for the winning or recovery of minerals from the sea bed.

A great deal of attention has been given recently to underwater mining of the sea bed, which includes the recovery of manganese nodules by entraining the nodules within a conduit suspended from a sea-going mining vessel. The conduit may have a gathering head contacting the sea bed and a discharge head mounted upon the mining vessel. A great quantity of air and sea water is entrained, along with the nodules, and this has to be separated from the nodules at the discharge head aboard the mining vessel. Thus, it is often necessary to effect separation of a foaming, three-phase mixture of gas, liquid and solids. Such a separation can be very difficult to carry out, particularly on board a sea-going vessel.

According to one aspect of this invention, a method is provided for separating solid particles from a fluid mixture comprising particulate solids in suspension in a liquid, which comprises discharging a stream of the fluid mixture within a foraminous-walled chamber in a direction substantially tangential to the interior surface of the chamber at the point of discharge, downwardly guiding the discharge stream in a helical path around the inner surface of the chamber wall, confining the solid particles within the chamber and permitting the discharge of liquid outwardly through the foraminous wall as the mixture is helically guided downwardly, and recovering the particulate solids from within the chamber after the liquid is discharged.

The invention also consists in seabed ore particles when obtained by operation of the method of the invention.

According to another aspect of the invention, an apparatus for separating solid particles from a liquid comprises a fluid inlet arranged to direct a flow of a fluid comprising the solid particles in a liquid into the upper end of a foraminous walled tube in a direction generally tangential to the wall of the tube, a helical guide within the tube connected to the tube at the first inlet at a point which in use lies above the flow and extending downwardly through the chamber adjacent the inner surface of the foraminous wall, the central portion of the chamber being open and otherwise free of impediment to downward flow and means for collecting the solid particles at the other end of the tube.

By operation of the method and apparatus of the present invention, solid particles can therefore be separated from a mixed fluid stream flowing at a high linear velocity, comprising a liquid and entrained solid particles. In a usual embodiment of the invention, the stream is a three-phase gas-liquid-solid mixture formed of a foaming stream of liquid and gas in which are suspended solid particles. Generally, in carrying out the method of the invention, a liquid-solid stream is discharged within a foraminous-walled tube, in a direction substantially tangential to the interior surface of the tube, the liquid thus discharging through the foraminous walls of the tube, as the stream moves helically around the inner surface of the tube; this

results in the solid phase being confined within the tube and the solids can be recovered from within the cylinder after the liquid is removed. Generally, the foraminous tube is arranged with its axis in a vertical direction and the stream is discharged into the tube with a downward component of velocity. Preferably, the liquid discharged through the foraminous tube is collected and separted from any gas phase present by permitting the discharged liquid to strike the inner nonporous surface of an outer container surrounding the foraminous tube, resulting in the breaking up of foam. The inner surface of the container wall should therefore be sufficiently close to the foraminous tue. The gas phase passes out in an upwardly direction and the liquid passes downwardly through the space between the foraminous wall and the outer container To avoid the entrainment of liquid in the upward flow of gas, the liquid passing through the foraminous wall is preferably directed downwardly by deflectors at the wall, the liquid can be collected from the bottom of the space.

Generally, collection means may be provided at the bottom of the foraminous tube to collect the solid particles. Similarly, collection and delivery means may be provided at the bottom of the outer container for collecting and removing liquid. The outer container is preferably cylindrical and substantialy coaxial with the inner foraminous tube.

According to the invention, the stream including the solid particles is guided in a generally helical path as it passes downwardly within the foraminous tube, thus gradually decreasing the velocity of the particles so as to decrease the impact experienced by the particles. This avoids breakage of the particles into small particles, or fines, which may be less desirable or more difficult to handle. By guiding the stream of particles so as to slow them down, the method and apparatus of the invention can be utilized for separating liquid-solid streams having a wide range of linear velocities.

Apparatus for separating solid particles from a liquid in which they are entrained in accordance with this invention typically comprises a generally cylindrical tube having a foraminous wall, a fluid inlet designed and arranged to direct a flow of fluid into the upper end of the tube in a direction generally tangential to the wall of the tube, the fluid tending to flow in a generally helical direction downwardly along the inner surface of the tube wall, the liquid passing outwardly through the foraminous wall and the solids passing downwardly within the tube. The helical guide is provided within the tube to guide the solid particles in a helical path downwardly, so that the solids progress down and generally parallel to the longitudinal axis of the tube. This helical guide is preferably adjacent to the inner surface of the foraminous wall of the tube at the inlet. Although this apparatus is designed to separate out solids from fluid streams moving at high linear velocities, it is often desirable to decrease the velocity of the fluid streams before passing them through the inlet into the foraminous-walled tube. To accomplish this, a curved, spiral or helical conduit may be provided in fluid flow connection to, and upstream of, the fluid inlet. For best results, the fluid flow inlet has a polygonal, especially a quadrilateral, cross-section; the conduit immediately connected to the inlet has the same cross-section. Generally, circular cross-sectioned pipe can be connected to the polygonal pipe by known means.

The foraminous wall can be a mesh formed by vertical and horizontal members. The mesh openings should be sufficiently small to prevent passage of the solid particles to be separated. The length and diameter of this tube, and the porosity, should be such as to permit passage of substantially all of the liquid so as to separate it from the solid particles.

This invention is especially effective for the separation of ocean floor nodule ore from sea water. Ocean floor nodule particles are often dredged up from the ocean floor by an airlift pumping system in a three-phase air-water (foam)- solid system. The holes, or mesh openings, should be of a size insufficient to pass most of the nodules or particles, although it is recognized that any fines present may be discharged with the fluid.

In order that the invention may be readily understood, reference is made below to the accompanying drawings, which show a preferred form of the apparatus of the invention and illustrate how the method of the invention may be performed; in the drawings:

Fig. 1 shows a front elevation of the apparatus; partialy in section, illustrating the mounting of a helical deflector within a cylindrical cage; which constitute important components of the separating apparatus; this view is taken on the line 1-1 of Fig. 2;

Fig. 2 shows a top plan of the apparatus of Fig. 1;

Fig. 3 shows a front elevational view of the spiral deflector;

Fig. 4 shows a fragmentary elevational view of the mounting of the inlet opening and helical deflector within the horizontal rings, taken on the line 4-4 of Fig. 2;

Fig. 5 shows an elevational view, partially in section and on an enlarged scale as compared with Fig. 4, illustrating how the

horizontal rings are mounted with respect to spray deflectors and support members; and

Fig. 6 shows a detail on an enlarged scale of the mounting of the bolted manhole at the bottom of the casing.

Referring to the drawings, an outer cylindrical casing 20 is provided, having an angle iron stiffener ring 30 at its top and supporting a foraminous cage 21 by means of a plurality of brackets 36, 38. The casing 20 is mounted upon 6″ × 6″ × 1/2″ angle iron legs 22, 24, 26 and 28 (Figs. 1 and 2). A circular intake pipe 32 carrying in a flanged bracket 33 is mounted in the wall of the casing 20 and merges into a curved conduit 34 having rectangular crosssection via a butt weld connection 35, so as to define a rectangular discharge port 40 (Fig. 4) measuring, say 9″ × 12″. A helical guide or deflector 42 extends downwardly from the port 40 towards the bottom of the cage 21. The deflector 42 attached to the upper edge of the port 40 carries a single downwardly-extending helical flange 44 on its inside edge, its outside edge 46 being welded to a series of 1/4″ × 1/2″ × 36″ diameter horizontal rings 68, which define the cage periphery. The rings 68 are connected, e.g. welded, to 2″ × 1/4″ vertical supports 48. A plurality of downwardly and outwardly inclined spray deflectors 50, 52, 54, 56, 58 and 60 are secured to the outside of the supports 48. A support apron 66 is mounted at the bottom of the cage 21 and includes a plurality of 2″ × 1/4″ brackets 62 and 64 which extend inwardly to support a nodule discharge cone 70. A 21″ O.D. cone extension 72 containing an axial pipe 24 leads to an axial nodule recovery bin (not illustrated).

A bottom pan 74 for the apparatus is supported around the cone extension 72 upon an inclined axis, such that the lowest part of its rim is supported 18″ beneath its uppermost part. A standard pipe drain 76 leads from the lowest region of the pan 74, so that water discharge centrifugally through the sides of the cage 21 and into the annulus 23 defined between the cage 21 and the inside wall of the housing 20 drains from the apparatus. A manhole cover 78 is bolted onto the casing 20, as illustrated in Fig. 6, by means of a number of square head bolts 80 tack welded to the side of casing 20 and having a 1/4″ rubber gasket 81 with nut and washer assemblies 82. The manhole cover 78 can be removed to provide access to the interior.

The illustrated device has separated nodules from sea water under ambient conditions at a rate of 60 tons of nodules per hour.

The apparatus shown and described is operated as follows: The separating apparatus is mounted upon a sea-going mining vessel and constitutes the upper output end of a conduit suspended from the vessel and having a gathering head as its lower input end. The conduit typically is an airlift pumping system. The mining vessel is positioned over an area of the sea bed where mining is to be carried out, e.g. an area where the floor of the ocean is known to be rich in manganese nodules or other economically recoverable sea bed mineral material. Operation of the airlift pump causes the manganese nodules to be suspended in a foam-containing suspension comprising air and and seawater, which carries the manganese nodules up to the vessel.

The air-seawater-solids suspension is fed from the conduit to the intake pipe 32 of the separating apparatus where the suspension is conveyed to the rectangular intake pipe 34, the direction of flow of the suspension being both downward with respect to the axis of the cylindrical casing 20 and tangential with respect to the inside of the cage 21. The suspension thus travels downwardly within the cage 21 along a helical path, the cage 21 allowing the air and liquid to pass through to the space 23, while retaining the solids, i.e. the manganese nodules, within the cage. The helical deflector 42 located within the cage 21 serves as a guide for maintaining the helical path of the stream of suspension within the cage 21. The air and liquid pass out between the rings 68 and the supports 48 of the cage 21 and impinge upon the deflectors 50, 52, 54, 56, 58 and 60. These direct the liquid downwardly of the cage 21 and also ensure that liquid is not entrained with the air. The liquid also strikes the inside of the casing 21 and this impact assists in breaking up any foam associated with the suspension and passing out through the mesh construction formed by the rings 68 and supports 48 of the cage 21.

As a result of treatment of the air-sea-water-manganese nodules in the apparatus, the air is discharged from the top of the casing 20, the seawater collects on the bottom pan 74 and drains into the pipe drain 76, while the manganese nodules fall into the discharge cone 70 and are directed by it into the extension 72 for collection in storage or transport receptacles, e.g. ore carrying compartments within the mining vessel.

WHAT WE CLAIM IS:

1. A method of separating solid particles from a fluid mixture comprising particulate solids in suspension in a liquid, which method comprises discharging a stream of the fluid mixture within a foraminous-walled chamber in a direction substantially tangential to the interior surface of the chamber

at the point of discharge, downwardly guiding the discharge stream in a helical path around the inner surface of the chamber wall, confining the solid particles within the chamber and permitting the discharge of liquid outwardly through the foraminous wall as the mixture is helically guided downwardly, and recovering the solid particles from within the chamber after the liquid is discharged.

2. A method according to claim 1, in which the liquid discharged through the foraminous wall is collected.

3. A method according to claim 1 or 2, in which the liquid discharging through the foraminous wall is directed downwardly against a surface surrounding the foraminous wall, in order to release gas entrained in the liquid.

4. A method according to any preceding claim, in which the fluid stream is passed through a helical conduit having a polygonal cross-section prior to being discharged into the chamber.

5. A method according to any preceding claim, in which the fluid mixture comprises a three-phase foaming fluid including water, air and ocean floor nodule ore particles and is the effluent from an airlift pumping system.

6. A method according to claim 5, in which the fluid mixture contains manganese ore nodules.

7. A method according to claim 1, substantially as described with reference to the accompanying drawings.

8. Seabed ore particles when obtained by a method according to any preceding claim.

9. An apparatus for separating solid particles from a liquid, comprising a fluid inlet arranged to direct a flow of a fluid comprising the solid particles in a liquid into the upper end of a foraminous-walled tube in a direction generally tangential to the wall of the tube, a helical guide within the tube connected to the tube at the fluid inlet at a point which in use lies above the flow of fluid and extending downwardly through the chamber adjacent the inner surface of the foraminous wall, the central portion of the chamber being open and otherwise free of impediment to downward flow and means for collecting the solid particles at the other end of the tube.

10. An apparatus according to claim 9, having a curved, spiral or helical conduit in fluid flow connection with the fluid inlet.

11. An apparatus according to claim 9 or 10, in which the foraminous wall of the tube comprises a series of horizontal members and vertical members operatively connected at their intersections to form a mesh.

12. An apparatus according to any of claims 9 to 11, in which the tube is located within an outer container so as to define a space between the tube and the container.

13. An apparatus according to claim 12, in which the container and the tube are substantially concentric cylinders.

14. An apparatus according to any of claims 9 to 13, in which deflectors are connected to the foraminous wall of the tube and are arranged for directing downwardly fluid discharging through the foraminous wall.

15. An apparatus according to claims 11 and 14, in which the deflectors comprise horizonttal bafflers connected to the outside of the mesh and inclined so as to direct a downwardly liquid discharging through the mesh.

16. An apparatus according to claim 9, substantially as described with reference to the accompanying drawings.

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1,396,151 COMPLETE SPECIFICATION
3 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEET 1

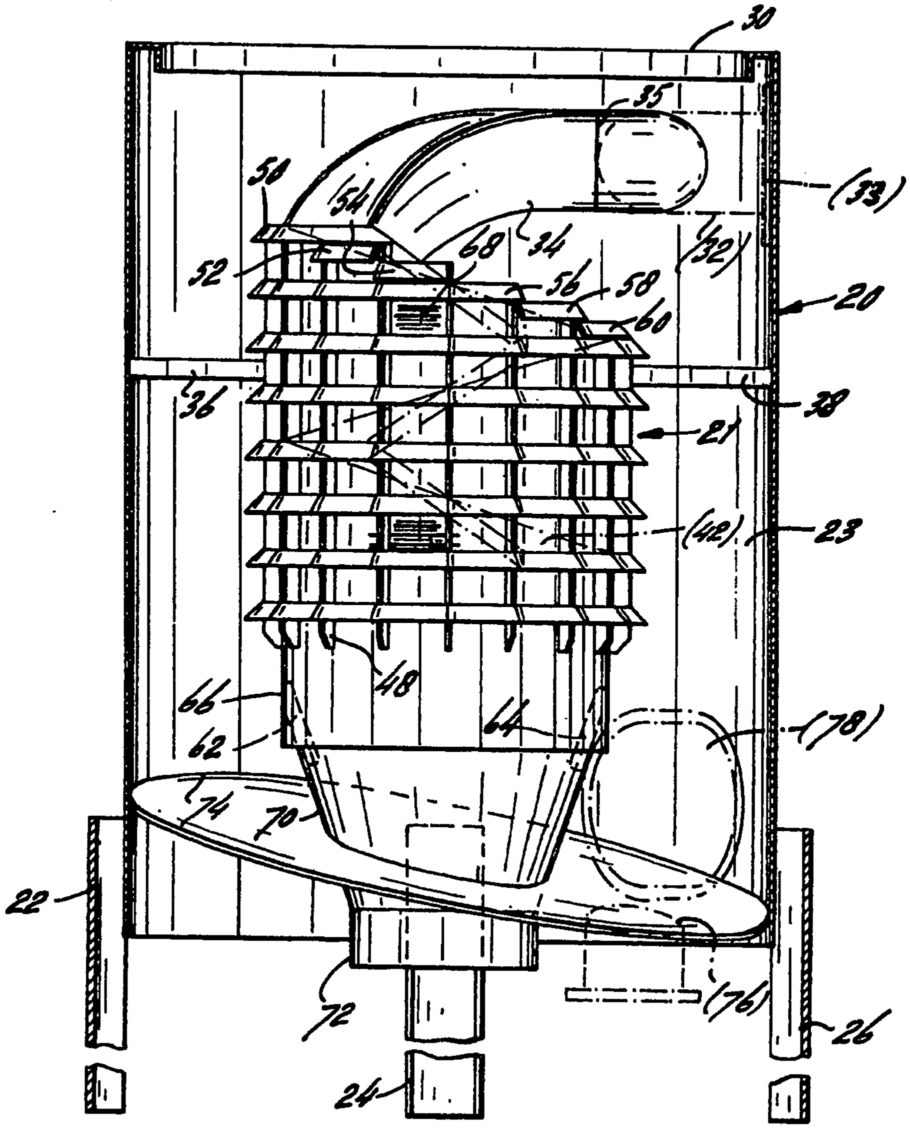

FIG. 1

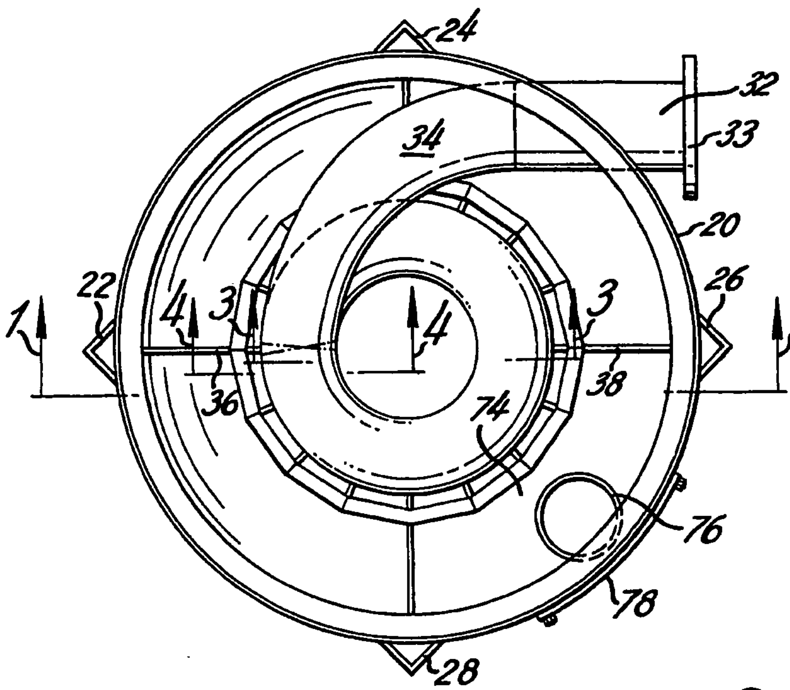

FIG.2

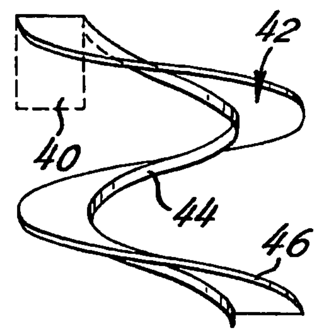

FIG.3

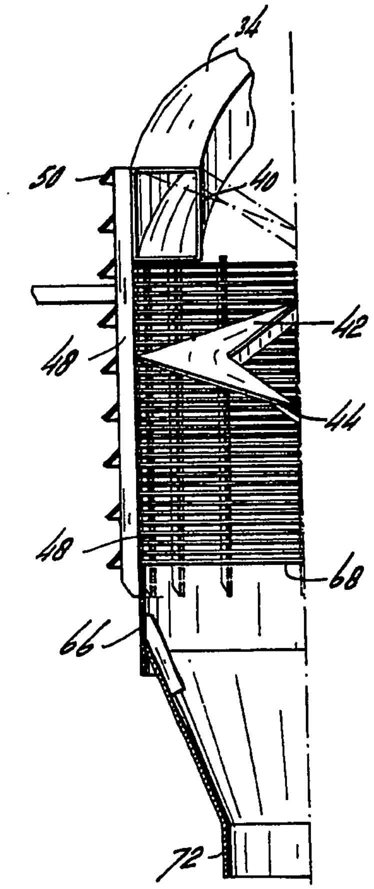

FIG. 4

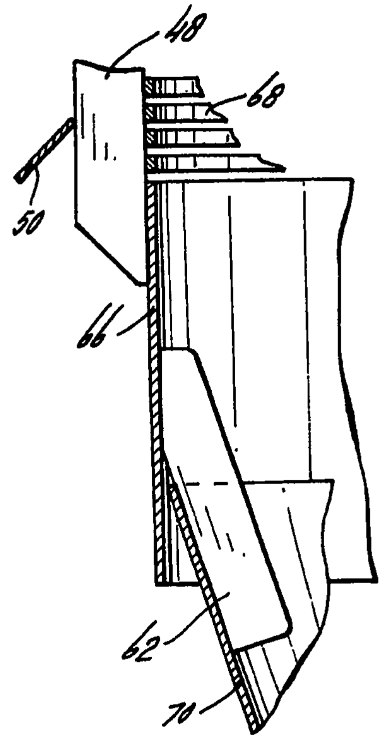

FIG. 5

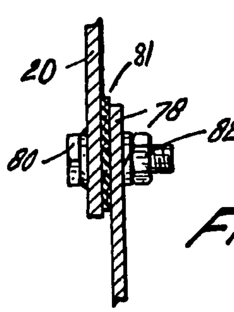

FIG. 6